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REPORT ON THE ILLINOIS RIVER SYSTEM. RECOMMENDED MEASURES FOR IMPROVING WATER QUALITY

PUBLIC HEALTH SERVICE
CHICAGO, ILLINOIS

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REPORT

ON

ILLINOIS RIVER SYSTEM

RECOMMENDED MEASURES FOR

IMPROVING WATER QUALITIES

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Measures by which conditions in the Illinois River system can be improved are discussed. The measures recommended are considered to be feasible and reasonable. Topics covered include treatment of municipal wastes, reduction in industrial waste discharges, combined sewers, research toward more efficient treatment methods, flexibility in diversion, and the Thomas J. O'Brien Locks. A Bibliography is included.

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REPORT

ON THE

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RECOMMENDED MEASURES FOR

IMPROVING WATER QUALITY

January 1963

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service

Division of Water Supply and Pollution Control

Great Lakes-Illinois River Basins Project

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INTRODUCTION

A previous report, "Water Quality Conditions," described the existing condition of the Illinois River System as determined from physical, chemical, biological, and bacteriological determinations. Another report, "Water Quality Goals," set forth desirable water quality goals for these waters. The purpose of this report is to present and discuss measures by which conditions in the river system can be improved. The measures recommended herein are considered to be feasible and reasonable.

The total carbonaceous biochemical oxygen demand (BOD) waste load to the Illinois River System, as previously presented, is 2,420,000 population equivalent (PE), of which 1,450,000 PE is from municipal sources and 970,000 PE is from independent industrial discharges. Of this total discharge, 770,000 PE or about 32 per cent of the total is from the three principal sewage treatment plants of the Metropolitan Sanitary District of Greater Chicago (MSD). This share contributed by these plants is large in spite of the fact that they provide efficient secondary treatment (about 90 per cent removal).

The improvement measures discussed in this report are presented only for the entire Upper Illinois River Basin above Lockport, and the main stem between Lockport and Grafton, since it has been determined from field measurements that other tributary streams do not contribute significantly to the water quality problems in the Illinois River at this time.

An adequate water pollution control program involves the enactment and administration of pollution control legislation as well as provision and operation of treatment works, and therefore the recommendations presented in this report involve the administrative as well as the collection and treatment aspects of waste disposal.

TREATMENT OF MUNICIPAL WASTES

Present Conditions

Present municipal sewage plant effluents discharged to the Illinois River System above the confluence of the Des Plaines River and the Sanitary and Ship Canal (Mile 290) total 930,000 PE. Of this total, about 89 per cent is from sources in the Metropolitan Sanitary District of Greater Chicago. The three large MSD treatment plants discharge 770,000 PE, or 83 per cent of the total effluent PE mentioned above. Consequently, the MSD plants and the loadings from the area they serve are major factors in consideration of river system conditions and their improvement.

Because there are practically no dilution flows aside from direct or indirect Lake diversion in the River System above the Des Plaines River confluence, the highest degree of sewage treatment which can be reasonably obtained should be provided.

The activated sludge process is recognized by competent sewage treatment authorities (1) as capable of removing approximately 90 per cent of the biochemical oxygen demand (BOD) in typical waste waters. In order to obtain a greater BOD removal, it is necessary to resort to some type of additional treatment. The activated sludge process is effectively applied at the present time by the three large MSD treatment plants; the average BOD removal is approximately 90 per cent. However, the present sewage treatment methods employed by the MSD and other municipalities are not sufficient to prevent pollution of the River System.

Sixteen of the 165 sewage works in the area above Lockport provide less than secondary treatment. The effluent discharges to streams from these 16 works comprise about 48,000 PE of the total 930,000 PE previously stated. Four of the works provide primary treatment, and the remaining twelve provide minor or no treatment. Two of the areas now served by temporary local MSD primary plants will be connected to the principal sewer system when interceptor sewers are extended to these areas, as will two additional areas where no treatment is provided at the present time. The third primary plant was recently constructed on provisional approval pending upstream developments. The remaining eleven works provide little or no treatment. Most of these are under orders to abate pollution and have started planning to correct this situation. These should be pursued to early correction by the State and local authorities involved.

Along the main stem of the Illinois River System below Lockport, 43 of 127 sewage works provide secondary treatment; 16 provide primary treatment; and the remaining 68 provide minor or no treatment. The total load discharged to the stream is 230,000 PE, of which secondary treatment plants discharge 60,000 PE and the remaining plants contribute 170,000 PE.

Planned Improvement Program by Metropolitan Sanitary District

The first phase of preparation of a long range program by the MSD is contained in a report of March 22, 1961(2) and a supplement of

March 29, 1961 (3). These concern individual replacements and new work contemplated principally for some 86 proposed projects during a ten-year period 1961-1970, and for some work beyond 1970. The program envisions continuation of central treatment of the bulk of MSD municipal sewage wastes in the three existing large treatment plants: the North Side, Calumet, and West-Southwest Plants. Various small plants will continue to serve isolated areas until population increase warrants the extension of interceptors to connect such areas to the three large plants. The individual projects concern extensions, replacements, enlargements, and additions to pump stations, interceptor systems, and treatment works. The proposed improvements are designed to serve an additional 1,500,000 persons. They include expansion of the capacities of the three large plants together with a number of replacements, additions, and improvements in components of the activated sludge and sludge treating and disposal units. In addition to improvements to conventional sewage treatment plants, the program proposes four stream aeration installations. One experimental aerator was operated during 1962.

Additions to capacity of the three major treatment works, as reflected in the proposed aeration basin and final settling tank additions, are as follows:

Proposed Capacity Increases - Three MSD Plants

Plant	Imp. Proposed	Const. Start	Const. Complete	Capacity Expansion From - To (MSD)
North Side	4th Aer. & Set. Tks.	(a)	1962	250 - 330
Calumet	3rd Aer. & Set. Tks.	1963	1965	136 - 204
West-S.W.	4th Aer. & Set. Tks.	1963	1966	900 -1200

(a) Now in operation.

Some of the interceptors now serving mostly suburban portions of Cook County are receiving loads approaching design capacities. The proposed interceptor system improvements will serve new communities now being developed as well as communities now served by small local treatment plants. Until actual population increases catch up with plant and interceptor expansions, a benefit will develop through ability, in the interim, to treat a greater portion of sewage now bypassed in storm spillage. Another benefit will develop through the requirement that areas (mostly suburban) building new sewer systems that will be connected to MSD interceptors, construct separate systems so that storm water will not be imposed on the interceptors.

Additional Improvements

Effluent Disinfection

The disposal of sewage containing pathogenic organisms into surface watercourses creates a public health hazard. The principal uses of the Upper Illinois River System are commercial shipping, cooling, and waste-water assimilation and transport. It is also used for recreational boating, but this use generally is limited to vessels in transit between Lake Michigan and the Lower Illinois River. The Lower

Illinois River is used for recreational activities and municipal water supply. To minimize the potential health hazard associated with these uses, a reduction in coliform densities is needed. Desirable quality goals for the Illinois River System with respect to its uses were set forth in a previous report.

The MSD should undertake an extensive study of methods to attain the recommended goal on stream coliform density. Two possible procedures that warrant immediate investigation are disinfection of the canal system at several locations, and disinfection of sewage treatment plant effluents and storm water overflows.

Stream Aeration

In addition to the present study by the MSD of mechanical stream aeration, aeration of the South Fork of the South Branch of the Chicago River should be investigated. The South Fork is a navigable channel about 1.2 miles long with no natural flow. The only significant source of waste is at the dead end where the Racine Avenue lift station, using the South Fork as a discharge channel, discharges combined sewage during periods of heavy rainfall and when there are operating difficulties at the West-Southwest Sewage Treatment Plant. Aeration of the South Fork would convert this channel from an anaerobic to an aerobic system, and thus would provide for more rapid assimilation of organic wastes.

Tertiary Treatment

The BOD reduction accomplished by the Metropolitan Sanitary District Treatment Plants is satisfactory for plants employing the activated sludge method as the secondary treatment process, but significant additional improvement of the effluent can be accomplished by subjecting the present effluent to a third stage of treatment.

This third stage of treatment could conceivably consist of rapid sand filtration or micro-straining as practiced in the water purification field. Results obtained from experimental work conducted at Los Angeles have been very promising, as have the results from experiments at Luton, England. From the conclusions reported from these experiments, it is reasonable to assume that up to 50 per cent removal of BOD from secondary effluent could be attained. It is recommended that the Metropolitan Sanitary District institute studies to determine the feasibility of the use of third-stage treatment at the treatment plants.

Cooling Water Use

In maintaining a dissolved oxygen goal in a stream containing a residual organic pollution load, it is generally recognized that greater dilution flows are required under warm summer water temperature conditions than under cold winter water temperatures. The reason lies in the lower dissolved oxygen saturation values and the higher rates of biological activity at the higher temperatures. Temperature observations made during the sample collection program showed a rise of 9°C in temperature through the Sanitary and Ship Canal. This rise may be attributed to a combination of a natural increase in the cool

lake temperatures plus the use of the water for cooling by air conditioning and thermal power installations. The importance of this factor increases as the temperature rise becomes greater and as the dissolved oxygen goal is set higher.

To assure the preservation of the stream's capacity to assimilate organic waste residues without nuisance conditions, it is important that use of the flow in the Sanitary and Ship Canal for cooling water by air conditioning, industrial, and thermal power installations be regulated and limited.

REDUCTION IN INDUSTRIAL WASTE DISCHARGES

The known and evaluated sources of industrial wastes discharged directly to the Illinois River System is 971,000 PE as detailed in a previous report. A load of 511,000 PE is contributed to the river system between Lake Michigan and the Kankakee River, and 460,000 PE is contributed in the section from the Kankakee River to the Spoon River. There is no significant industrial pollution to the river system below the junction of the Spoon River.

This industrial pollution is contributed chiefly by the highly industrial areas of Chicago, Joliet, and Peoria-Pekin. The known and evaluated sources of industrial wastes discharged directly to the river system within the boundaries of the Metropolitan Sanitary District total 291,000 PE or approximately 30 per cent of the total industrial load. The industrial load contributed in the Peoria-Pekin area is 400,000 PE or approximately 40 per cent of the total load. The industrial load contributed in the Joliet area is 178,000 PE or approximately 20 per cent of the total load. The remaining 10 per cent of the industrial load is contributed to the tributaries and other sections of the river.

Chicago Area

The total waste load, domestic and industrial, to the three principal sewage treatment plants of the Metropolitan Sanitary District is 8,030,000 PE. The population served by these plants is 4,750,000. The difference, industrial wastes and other wastes treated by the plants, is 3,280,000 PE.

The known and evaluated sources of industrial wastes discharged directly to the Illinois River System within the boundaries of the MSD total 291,000 PE. A comprehensive survey of visible independent outfalls to the river system conducted by MSD indicated about 1300 such outfalls. Over 400 of these outfalls were observed and sampled by the Public Health Service and 140 outfalls were found to be contributing a significant load to the river. The significant outfalls have been included in the inventory presented in a previous report. The existence and number of submerged outfalls is unknown.

Extensive sampling by the Public Health Service of the waterways between Wilmette and Lockport (North Shore Channel, North Branch Chicago River, Chicago River, South Branch Chicago River, and Sanitary and Ship Canal) has indicated a pollutional load of approximately 400,000 PE in addition to the known loads from sewage treatment plants, Calumet-Sag Channel, and other influent streams. The known industrial waste load in the same section of the river is 225,000 PE. The difference between the industrial waste estimate of 225,000 PE and the known pollution load of 400,000 PE is attributed to storm-water overflow, by-passing untreated sewage, and unaccounted-for sources.

The MSD prohibits by ordinance (4)(5) the discharge to the waters of the district of wastes that are more concentrated than the effluent from the sewage treatment works of the district.

The MSD controls the quality and quantity of industrial wastes admitted to the sewage works, watercourses, or natural outlets within the boundaries of the Sanitary District in accordance with provisions of the MSD Ordinance of July 13, 1962 (5).

Industries discharging wastes to the MSD sewerage system are now subject to a charge based on their assessed valuation. A system of sewer service charges based on the quantity and characteristics of discharged wastes would induce industries to decrease the quantity and strength of their wastes by altering manufacturing methods, improving housekeeping practices, developing of new treatment and/or pre-treatment procedures, reusing waste water, segregating cooling water, and other methods of minimizing charges. The City of Cincinnati made a five-year study from 1954 to 1958 to determine the effectiveness of such a method of assessing sewer charges in reducing the industrial waste load (6). The Cincinnati survey represented a cross-section of heavy industry similar to that served by the MSD. The survey indicated that the volume of waste decreased about 10.4 per cent, the BOD about 13.3 per cent, and the suspended solids about 51.9 per cent.

The discharge of a portion of organic industrial wastes to the river system has been controlled by the Metropolitan Sanitary District by connecting the entire flow of waste from some plants into the sewerage system. However, in other cases the organic wastes have been segregated for discharge to the sewerage system, and larger flows relatively free of organic material have been allowed to flow to the river.

Many problems created by the discharge of industrial effluents to the river and sewerage system have been investigated by the MSD over the past 30 years. The MSD has conducted more than 900 separate studies of approximately 400 plants. The principal purpose of studying discharges to the sewerage system has been to detect and exclude such materials as oil, heavy metals, and others that interfere with proper operation of the treatment plants.

The industrial wastes program of the MSD is under the direction of the Director of Laboratories, who is responsible to the Chief Engineer. The number of people assigned to industrial wastes permits study of approximately 25 to 30 plants per year. The present staff and program of the MSD concerned with industrial waste discharges function effectively. However, enlarged operations are needed to provide complete surveillance of outfalls and industrial plant discharges to the river system.

Peoria-Pekin Area

The known and evaluated sources of industrial wastes discharged directly to the Illinois River in the Peoria-Pekin area is 400,000 PE. A survey of 43 outfalls in this area by the Public Health Service was made in order to verify this industrial waste load. Approximately 50 per cent of this load was found to be contributed by one source.

In general the highly concentrated industrial wastes are either connected to the sewerage systems or discharged to the river following pre-treatment. Some of the industries in this area recover valuable by-products from their waste waters.

Recommendations

1. The industrial waste program of the Metropolitan Sanitary District of Chicago should be expanded to permit more adequate surveillance of independent discharges to the river and the sewerage system.

2. Other municipalities along the Illinois River System should undertake industrial waste surveillance programs similar to the MSD program.

3. Industrial pollution should be decreased by treatment at the site if needed or by connection to a municipal sewerage system.

4. Comprehensive industrial waste ordinances should be adopted by all municipalities having sewerage systems to control the discharges of wastes to the sewerage systems.

COMBINED SEWERS

Present Conditions

Chicago Metropolitan Area

The Chicago combined sewer system includes over 3,600 miles of sewers serving 190 square miles and about 3.5 million population. Most suburban municipalities in the Metropolitan Sanitary District (MSD) are also served by combined sewer systems which discharge mixed sanitary and storm sewage to the Illinois River System during wet weather. There are about 200 overflows located on the main channels in the Chicago area, and an undetermined number on tributary streams.

The discharge of raw sewage and industrial wastes mixed with storm water during rainstorms constitutes a sizeable intermittent source of pollution to the waterways. Although the discharge of combined sewage at such times is of limited duration, solids deposited as sludge on the stream bed may persist and deplete the flowing water of dissolved oxygen (DO) for extended periods of time. The raw sewage discharged also contributes substantially to the flowing pollution load of the stream. This tends to depress the DO profile and extend the recovery time. Such sources of raw sewage contribute unsightly floating matter and create potential and actual hazards from pathogenic organisms.

Lower Illinois River

In the Lower Illinois River Basin there are 22 cities with a population of 5,000 or more which are served by combined sewers. The estimated total population served in this group is 438,000. In addition there are 12 cities in this population class which are served by both separate and combined sewers. The latter group includes Peoria, and the estimated total population served by separate and combined sewers in these cities is 371,000. Many smaller towns in the basin also have combined sewer systems. Needless to say, not all of these combined sewers overflow simultaneously. However, the discharge of raw sewage to the Illinois River is deleterious to the water quality, and is a potential hazard to public health.

Improvement Measures

Chicago Metropolitan Area

Methods by which reductions in combined sewage spillage could be accomplished are discussed below.

Separation of storm water and sanitary sewage at the source is probably the ultimate solution to the problem, but its implementation would be so complicated, time consuming, and costly that results would not be realized for a number of years. However, consideration should be given to a program similar to that in effect in Washington, D.C. (7), which provides for a master plan to coordinate all new building construction, private development, civic improvements, and

redevelopment into a program leading to the complete separation of storm and sanitary sewers. It is believed that within a few years many other cities will follow Washington's example. There is much new construction under way in Chicago, and it would be possible to provide separate sewers at the time areas are redeveloped, so that at some time in the future, when enough of the city has undergone such change, it would be practicable to connect these separate sanitary sewers directly to the interceptors, and to use the existing combined sewers for storm water only. A number of the suburban communities now served by the MSD have separate sewer systems. In some cases the two systems are so interconnected that separation would be very difficult and may not be justified at this time. A program of gradual separation could be started, however, which would result in complete separation in the future.

The industrial waste load to combined sewers could be reduced in areas where industries are located near an interceptor, by separating industrial and domestic wastes from storm water and delivering these wastes directly to the interceptor.

In general, the interceptors should have capacity for twice the average daily dry weather flow. When the interceptors become overloaded, more frequent spills occur. This is a problem associated with the rapid urban growth within the MSD. Studies should be made to determine whether the reduction of these overflows should be accomplished by construction of one or more large sewage treatment plants in the outlying areas, or by the construction of relief interceptors to transport the sewage to existing treatment plants.

Since the strength of sewage varies considerably in different parts of the collector system, consideration should be given to providing a higher interception ratio in areas where waste concentrations are greater. The Sanitary District now does this in some instances. Additional study would indicate where this method could be extended advantageously.

The existing treatment plants should have capacity to treat twice the average daily dry weather flow. The MSD has planned additions to the three main plants which will provide this capacity by 1970.

Primary sedimentation tanks for storm flow would be effective for reducing settleable solids and BOD. The maximum reduction in BOD with adequate retention time would be about 40 per cent (1) in the flow passing through the tanks. Detailed studies would be required to determine the economical size of storm water treatment plants in relation to their effect on the waterway. Such studies should also include the feasibility of disinfection for reduction of bacterial pollution.

Lower Illinois River

Possible measures for reduction of pollution due to combined sewers in municipalities in the Lower Illinois River Basin are listed below. Economic studies would be required in each case to determine the most suitable combination of measures.

Separation of storm and sanitary sewer systems.

Adequate design of new interceptors, and construction of relief interceptors where needed to reduce frequency of spills.

Provision of adequate design capacity at new or existing treatment plants.

Primary treatment tanks for storm flows.

OTHER QUALITY CONTROL MEASURES

Research Toward More Efficient Treatment Methods

The Chicago metropolitan area presents a challenging and exceedingly difficult water pollution control problem because of the tremendous waste loads and the scarcity of dilution water.

The Metropolitan Sanitary District of Greater Chicago, within which the great bulk of the loads originate, has provided sewage treatment facilities representative of the best available practical methods known for secondary treatment of organic waste discharges. These fail to eliminate the stream pollution problem, the effect of which is not only serious locally but also is potentially hazardous to downstream users.

There are major deficiencies in the best of current sewage treatment practices to control water pollution. The treated effluents contain nutrients which stimulate aquatic growths such as algal blooms and result in nuisances to downstream water users, persistent organic chemicals such as alkyl benzene sulfonate (ABS) which are not removed by water supply treatment processes, and suspended and dissolved organic residues that exert an oxygen demand in excess of the oxygen available in the limited amount of dilution water. Such are the conditions which exist in the Illinois River System in which the Chicago metropolitan area discharges its wastes. A breakthrough in knowledge of sewage collection and treatment methods is one of the avenues that can lead to the solution of these problems. The need for better technology is further highlighted by the recent finding of latent oxygen demand exerted in downstream reaches of the Illinois River. This latent demand, attributable to oxidation of nitrogen residues from upstream wastes, points to the need for serious study in the removal of more than carbonaceous matter.

The MSD has legal authority for water pollution control within its territory, along with a responsibility to downstream users to provide the solution to problems of water quality caused by the use of the Illinois River System for disposal of its wastes. It is therefore incumbent upon the district to be in the forefront of a vigorous program of research and development of advanced treatment methods.

The 1960 National Conference on Water Pollution (8) concluded that a much greater effort is needed to provide a scientific basis for technological progress in water pollution control and recommended a national research effort of 15 million dollars per year by 1970. It also pointed to the need for greater awareness and appreciation of research by the practitioners -- dischargers, regulators, designers, and educators as well as the general public. The conference further pointed up areas of research effort needed, including advanced treatment methods.

It is recommended that, in keeping with its responsibilities to provide adequate control of water quality for downstream uses, the MSD expand its program of research and development in advanced waste treatment methods.

Flexibility in Diversion

The Metropolitan Sanitary District is limited by Supreme Court decision to an annual average lake water diversion, exclusive of domestic pumpage, of 1,500 cubic feet per second (cfs). This allowable diversion includes an annual average of about 500 cfs of runoff to the waterway which would be tributary to Lake Michigan if the natural direction of flow of the streams involved had not been reversed. The annual average within each calendar year may not exceed the allowable 1500 cfs. The total flow in the waterway is measured at Lockport, and the diversion flow is computed by subtraction of domestic pumpage and inflows to the system from areas which were tributary to the Des Plaines River before the canals were built. The sanitary district (9) operates the system on an annual water budget with the objective of maintaining average monthly flows at Lockport which experience has shown to be consistent with seasonal conditions on the waterway, and with demands of navigation. The diversion in a typical year averages approximately 400 cfs at Wilmette, 500 cfs at mouth of Chicago River and 600 cfs at Blue Island Controlling Works.

Since one-third of the total diversion is uncontrolled runoff, the short-term diversion rates may differ radically from the annual averages given above, particularly during heavy runoff periods. At such times, direct diversion at Wilmette and at mouth of Chicago River may be discontinued. At Blue Island, diversion may be limited to that amount necessary to maintain navigation through the lock. These restrictions of flow are necessary to prevent flood damage along the channels during major storms.

Thus, one-third of the total diversion, on the average, is uncontrolled, and the use of the other two-thirds for dilution is restricted by the requirements of navigation and by the chance occurrence of rainfall. In any particular year the flow regulation necessitated by abnormal runoff, together with the limitations imposed by the Supreme Court, may result in degrading the waterway during a portion of the year.

Abnormal rainfall distribution during the year 1961 produced a condition which illustrates the point. Total rainfall during the first eight months of the year was 0.96 inches below the normal of 22.65 inches at Midway Airport, and the eight-month average diversion rate (1,618 cfs) was slightly above the allowable average for a whole year. During September a total of 14.17 inches of rainfall occurred, producing uncontrolled runoff which increased the average diversion flow to 1,774 cfs for the months January through September. It was then necessary for the sanitary district to reduce direct diversion to a minimum during October and November, 567 and 385 cfs respectively, in order to comply with the 1,500 cfs average requirements at the end of the year. Sampling runs were made on October 17 and 25, during the period of reduced diversion. Dissolved oxygen (DO) profiles for these dates are shown on Figure 1, together with the average DO profile for the sampling period April 24 - May 21, when average diversion was 1,800 cfs. Degradation of the stream during the period of reduced diversion is evident.

In order to improve the stream during conditions such as described above, it would be desirable to change the basic accounting period for diversion flows from the calendar year to a water year terminating at the end of February. The diversion flow required to maintain the DO objective at Lockport is much less during the winter months than during

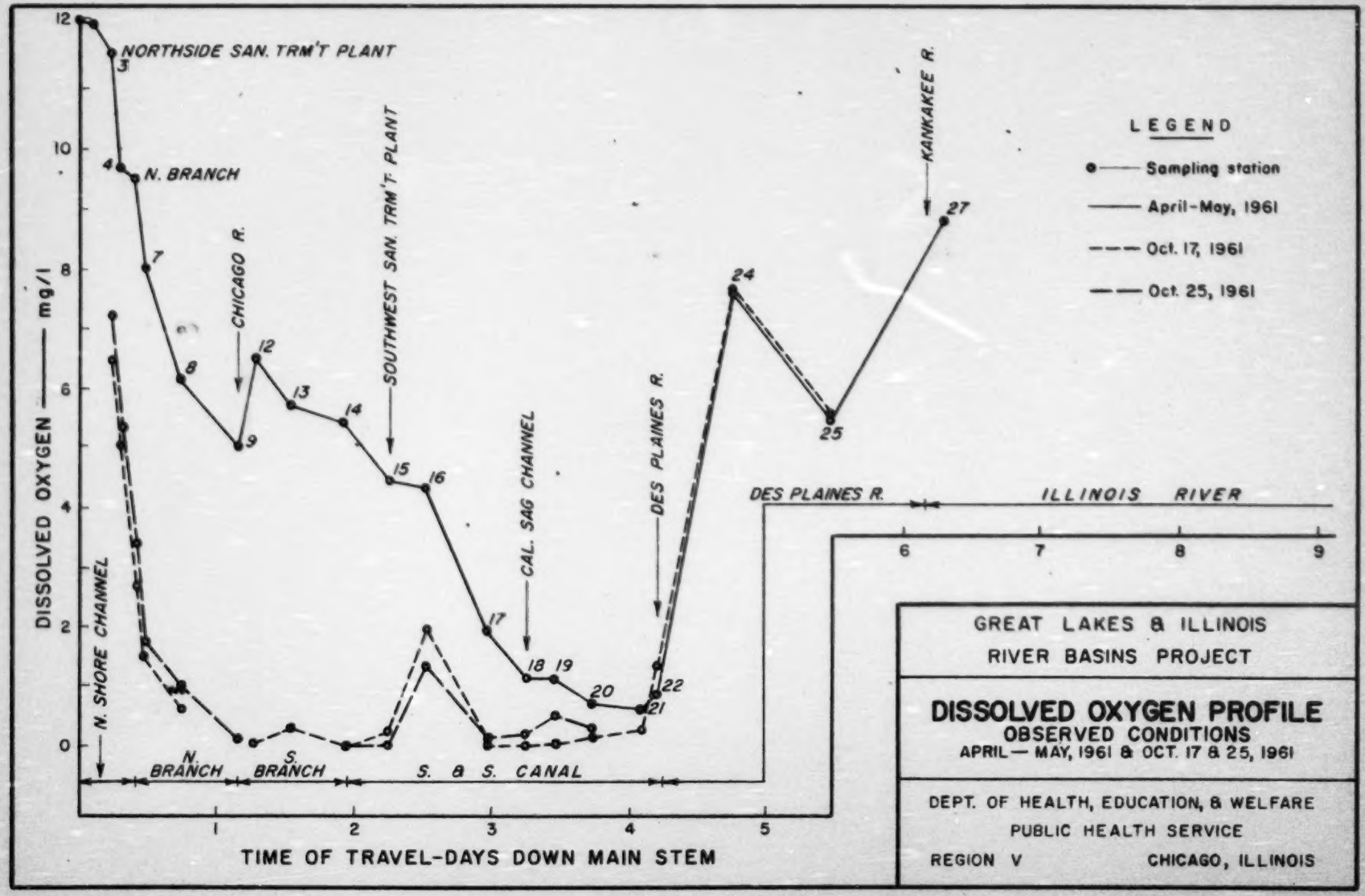

DISSOLVED OXYGEN — mg/l
TIME OF TRAVEL-DAYS DOWN MAIN STEM
NORTHSIDE SAN. TRM'T PLANT
N. BRANCH
CHICAGO R.
SOUTHWEST SAN. TRM'T. PLANT
CAL. SAG CHANNEL
DES PLAINES R.
KANKAKEE R.
N. SHORE CHANNEL
N. BRANCH
S. BRANCH
S. & S. CANAL
DES PLAINES R.
ILLINOIS RIVER
LEGEND
Sampling station
April-May, 1961
Oct. 17, 1961
Oct. 25, 1961
GREAT LAKES & ILLINOIS
RIVER BASINS PROJECT
DISSOLVED OXYGEN PROFILE
OBSERVED CONDITIONS
APRIL — MAY, 1961 & OCT. 17 & 25, 1961
DEPT. OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION V
CHICAGO, ILLINOIS

FIGURE 1

the remainder of the year, and it would be helpful if the months of low diversion demand were at the end of the accounting period. An analysis of the average monthly diversion flows for the period 1953-1960, compared to the average monthly flows required to maintain desirable DO levels at Lockport during the same period, indicates that the diversion water year should begin on March 1. This would permit a better utilization of the water available for dilution.

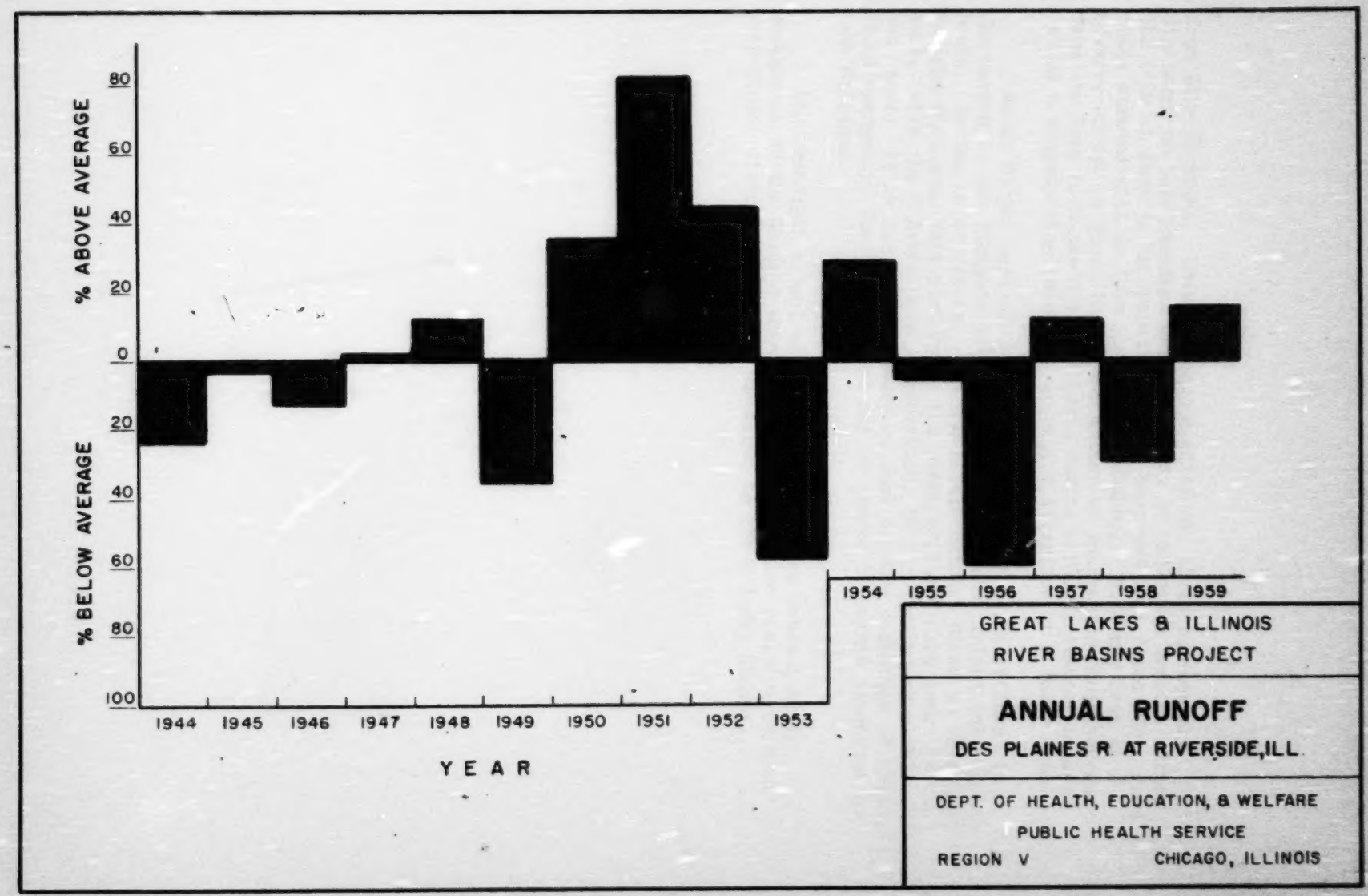
The extent to which the runoff may vary is indicated on Figure 2, which shows annual runoff in per cent above or below the average for the U. S. Geological Survey gaging station on the Des Plaines River at Riverside, Ill., during the period of record (1944-1959). The Des Plaines River Basin is adjacent to the area draining to the Sanitary Canal and both would receive essentially the same annual rainfall. Variations in average monthly flows are much more extreme and have a greater effect on actual operation of the waterway. Because of the large variations in flow which do occur, it is recommended that the accounting method be modified to permit two years for achieving the required balance, when necessary. In other words, on any March 1 when the average diversion for the preceding 24 months has not exceeded 1,500 cfs, two years would be available for achieving the next balance. Thus, the incentive would be to maintain the 1,500 cfs average in 12 months in order to have the subsequent 24 months available in case of emergency.

Thomas J. O'Brien Lock

The O'Brien Lock and Dam was constructed by the Corps of Engineers, U. S. Army, as a part of the Calumet-Sag Navigation Project. The new lock will replace the Blue Island Controlling Works, constructed in 1922 by the sanitary district. The O'Brien Lock is located on the Calumet River, Mile 326.5, about midway between the mouth of Grand Calumet River and the 130th Street Bridge. Four 10-foot square sluice gates are provided in the dam, which will serve to regulate flows from Lake Michigan to the Illinois Waterway, to prevent reversals of flow into Lake Michigan, and to permit better control of water levels landward of the lock.

At the present time, towboats are permitted to proceed through the Blue Island Lock under power with both lock gates open. This method of operation, necessitated by the inadequate size of the lock, permits a large uncontrolled flow from Lake Michigan, estimated to average about 600 cfs. With the O'Brien Lock in operation, all tows will be locked through in the conventional manner, with consequent reduction in water usage due to lockage requirements. It is estimated that about 150 cfs will be needed to operate the O'Brien Lock after completion of the Cal-Sag Navigation Project.

The Little Calumet and Grand Calumet Rivers enter the Illinois River System between the Blue Island and O'Brien Locks. These rivers were originally in the Lake Michigan watershed. As a result of the construction of the Cal-Sag Channel, they now contribute to the Illinois River System, and their flow is charged against the allowable diversion


% ABOVE AVERAGE
% BELOW AVERAGE
80
60
40
20
0
20
40
60
80
100
1944
1945
1946
1947
1948
1949
1950
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YEAR
GREAT LAKES & ILLINOIS
RIVER BASINS PROJECT
ANNUAL RUNOFF
DES PLAINES R. AT RIVERSIDE, ILL.
DEPT. OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION V
CHICAGO, ILLINOIS

FIGURE 2

SUMMARY

1. No less than secondary treatment should be provided for all sewage being discharged to the Upper Illinois River System and the main stem below Lockport.

2. The Metropolitan Sanitary District should undertake an extensive study to determine the best plan to attain the recommended goal on stream coliform density. The technical practicability of disinfecting the canal at several locations and/or the disinfecting of treatment plant effluents and storm water overflows should be studied.

3. The Metropolitan Sanitary District should continue its present experimental program of artificial reaeration of the river system in order to determine whether it is practical to increase oxygen concentrations by this method under the conditions that prevail.

4. The recently enacted industrial waste ordinance should be reviewed for possible revisions that will encourage industrial practices which minimize the quantity and strength of industrial wastes delivered to the MSD sewer system.

5. The Metropolitan Sanitary District should continue the program for the detection of unknown submerged outfalls, illegal connections to storm sewers, and other types of illicit connections.

6. The use of the canals in the Chicago area for cooling water by air conditioning, thermal power, and industrial installations should be regulated and limited.

7. The MSD and other responsible agencies should increase the emphasis given to research and development programs for improvement of treatment techniques and other measures to protect the quality of receiving waters.

8. The Metropolitan Sanitary District should immediately undertake comprehensive engineering studies to determine the best plan for the separation of storm and sanitary sewers, and the plan should be implemented as it becomes available. Suggested short-term improvements should be made in the meantime.

9. The "water year" for computation of the average allowable diversion should begin on March 1, and should continue for a two-year period if necessary for balancing the water account when circumstances dictate, to foster better utilization of the authorized diversion.

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REPORT

ON THE

ILLINOIS RIVER SYSTEM

RECOMMENDED MEASURES FOR IMPROVING WATER QUALITY

JANUARY, 1963

U. S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE

PUBLIC HEALTH SERVICE

DIVISION OF WATER SUPPLY AND POLLUTION CONTROL

GREAT LAKES-ILLINOIS RIVER BASINS PROJECT

ERRATA

Recommended Measures for Improving Water Quality

Page 1, second paragraph, first sentence.
Delete 1,450,000 PE: insert 1,590,000 PE.
Delete 970,000 PE: insert 830,000 PE.

Page 2, first paragraph, third line. Insert asterisk after 930,000 PE.
At bottom of page insert: *In addition to this stated load, a malfunctioning storm relief discharged an estimated 144,000 PE during the period of study.

Page 6, fourth paragraph, third line. Delete 291,000 PE; insert 147,000 PE.

Page 7, first paragraph, eighth and ninth lines. Delete 225,000 PE; insert 81,000 PE.

Recommended Measures for Improving Water Quality

ADDITIONAL ERRATA

Page 6, first paragraph, second line. Delete 971,000 PE; insert 827,000 PE.

Page 6, first paragraph, third line. Delete 511,000 PE; insert 367,000 PE.

Page 6, second paragraph, fifth line. Delete 291,000 PE; insert 147,000 PE. Delete 30; insert 20.

Page 6, second paragraph, seventh line. Delete 40; insert 50.

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REPORT ON THE ILLINOIS RIVER SYSTEM. RECOMMENDED MEASURES FOR IMPROVING WATER QUALITY

PUBLIC HEALTH SERVICE
CHICAGO, ILLINOIS

JANUARY 1963

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REPORT

ON

ILLINOIS RIVER SYSTEM

RECOMMENDED MEASURES FOR IMPROVING WATER QUALITIES

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16. Abstracts

Measures by which conditions in the Illinois River system can be improved are discussed. The measures recommended are considered to be feasible and reasonable. Topics covered include treatment of municipal wastes, reduction in industrial waste discharges, combined sewers, research toward more efficient treatment methods, flexibility in diversion, and the Thomas J. O'Brien Locks. A Bibliography is included.

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REPORT

ON THE

ILLINOIS RIVER SYSTEM

RECOMMENDED MEASURES FOR

IMPROVING WATER QUALITY

January 1963

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service

Division of Water Supply and Pollution Control

Great Lakes-Illinois River Basins Project

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INTRODUCTION

A previous report, "Water Quality Conditions," described the existing condition of the Illinois River System as determined from physical, chemical, biological, and bacteriological determinations. Another report, "Water Quality Goals," set forth desirable water quality goals for these waters. The purpose of this report is to present and discuss measures by which conditions in the river system can be improved. The measures recommended herein are considered to be feasible and reasonable.

The total carbonaceous biochemical oxygen demand (BOD) waste load to the Illinois River System, as previously presented, is 2,420,000 population equivalent (PE), of which 1,450,000 PE is from municipal sources and 970,000 PE is from independent industrial discharges. Of this total discharge, 770,000 PE or about 32 per cent of the total is from the three principal sewage treatment plants of the Metropolitan Sanitary District of Greater Chicago (MSD). This share contributed by these plants is large in spite of the fact that they provide efficient secondary treatment (about 90 per cent removal).

The improvement measures discussed in this report are presented only for the entire Upper Illinois River Basin above Lockport, and the main stem between Lockport and Grafton, since it has been determined from field measurements that other tributary streams do not contribute significantly to the water quality problems in the Illinois River at this time.

An adequate water pollution control program involves the enactment and administration of pollution control legislation as well as provision and operation of treatment works, and therefore the recommendations presented in this report involve the administrative as well as the collection and treatment aspects of waste disposal.

TREATMENT OF MUNICIPAL WASTES

Present Conditions

Present municipal sewage plant effluents discharged to the Illinois River System above the confluence of the Des Plaines River and the Sanitary and Ship Canal (Mile 290) total 930,000 PE. Of this total, about 89 per cent is from sources in the Metropolitan Sanitary District of Greater Chicago. The three large MSD treatment plants discharge 770,000 PE, or 83 per cent of the total effluent PE mentioned above. Consequently, the MSD plants and the loadings from the area they serve are major factors in consideration of river system conditions and their improvement.

Because there are practically no dilution flows aside from direct or indirect Lake diversion in the River System above the Des Plaines River confluence, the highest degree of sewage treatment which can be reasonably obtained should be provided.

The activated sludge process is recognized by competent sewage treatment authorities (1) as capable of removing approximately 90 per cent of the biochemical oxygen demand (BOD) in typical waste waters. In order to obtain a greater BOD removal, it is necessary to resort to some type of additional treatment. The activated sludge process is effectively applied at the present time by the three large MSD treatment plants; the average BOD removal is approximately 90 per cent. However, the present sewage treatment methods employed by the MSD and other municipalities are not sufficient to prevent pollution of the River System.

Sixteen of the 165 sewage works in the area above Lockport provide less than secondary treatment. The effluent discharges to streams from these 16 works comprise about 48,000 PE of the total 930,000 PE previously stated. Four of the works provide primary treatment, and the remaining twelve provide minor or no treatment. Two of the areas now served by temporary local MSD primary plants will be connected to the principal sewer system when interceptor sewers are extended to these areas, as will two additional areas where no treatment is provided at the present time. The third primary plant was recently constructed on provisional approval pending upstream developments. The remaining eleven works provide little or no treatment. Most of these are under orders to abate pollution and have started planning to correct this situation. These should be pursued to early correction by the State and local authorities involved.

Along the main stem of the Illinois River System below Lockport, 43 of 127 sewage works provide secondary treatment; 16 provide primary treatment; and the remaining 68 provide minor or no treatment. The total load discharged to the stream is 230,000 PE, of which secondary treatment plants discharge 60,000 PE and the remaining plants contribute 170,000 PE.

Planned Improvement Program by Metropolitan Sanitary District

The first phase of preparation of a long range program by the MSD is contained in a report of March 22, 1961(2) and a supplement of

March 29, 1961 (3). These concern individual replacements and new work contemplated principally for some 86 proposed projects during a ten-year period 1961-1970, and for some work beyond 1970. The program envisions continuation of central treatment of the bulk of MSD municipal sewage wastes in the three existing large treatment plants: the North Side, Calumet, and West-Southwest Plants. Various small plants will continue to serve isolated areas until population increase warrants the extension of interceptors to connect such areas to the three large plants. The individual projects concern extensions, replacements, enlargements, and additions to pump stations, interceptor systems, and treatment works. The proposed improvements are designed to serve an additional 1,500,000 persons. They include expansion of the capacities of the three large plants together with a number of replacements, additions, and improvements in components of the activated sludge and sludge treating and disposal units. In addition to improvements to conventional sewage treatment plants, the program proposes four stream aeration installations. One experimental aerator was operated during 1962.

Additions to capacity of the three major treatment works, as reflected in the proposed aeration basin and final settling tank additions, are as follows:

Proposed Capacity Increases - Three MSD Plants

Plant	Imp. Proposed	Const. Start	Const. Complete	Capacity Expansion From - To (MSD)
North Side	4th Aer. & Set. Tks.	(a)	1962	250 - 330
Calumet	3rd Aer. & Set. Tks.	1963	1965	136 - 204
West-S.W.	4th Aer. & Set. Tks.	1963	1966	900 -1200

(a) Now in operation.

Some of the interceptors now serving mostly suburban portions of Cook County are receiving loads approaching design capacities. The proposed interceptor system improvements will serve new communities now being developed as well as communities now served by small local treatment plants. Until actual population increases catch up with plant and interceptor expansions, a benefit will develop through ability, in the interim, to treat a greater portion of sewage now bypassed in storm spillage. Another benefit will develop through the requirement that areas (mostly suburban) building new sewer systems that will be connected to MSD interceptors, construct separate systems so that storm water will not be imposed on the interceptors.

Additional Improvements

Effluent Disinfection

The disposal of sewage containing pathogenic organisms into surface watercourses creates a public health hazard. The principal uses of the Upper Illinois River System are commercial shipping, cooling, and waste-water assimilation and transport. It is also used for recreational boating, but this use generally is limited to vessels in transit between Lake Michigan and the Lower Illinois River. The Lower

Illinois River is used for recreational activities and municipal water supply. To minimize the potential health hazard associated with these uses, a reduction in coliform densities is needed. Desirable quality goals for the Illinois River System with respect to its uses were set forth in a previous report.

The MSD should undertake an extensive study of methods to attain the recommended goal on stream coliform density. Two possible procedures that warrant immediate investigation are disinfection of the canal system at several locations, and disinfection of sewage treatment plant effluents and storm water overflows.

Stream Aeration

In addition to the present study by the MSD of mechanical stream aeration, aeration of the South Fork of the South Branch of the Chicago River should be investigated. The South Fork is a navigable channel about 1.2 miles long with no natural flow. The only significant source of waste is at the dead end where the Racine Avenue lift station, using the South Fork as a discharge channel, discharges combined sewage during periods of heavy rainfall and when there are operating difficulties at the West-Southwest Sewage Treatment Plant. Aeration of the South Fork would convert this channel from an anaerobic to an aerobic system, and thus would provide for more rapid assimilation of organic wastes.

Tertiary Treatment

The BOD reduction accomplished by the Metropolitan Sanitary District Treatment Plants is satisfactory for plants employing the activated sludge method as the secondary treatment process, but significant additional improvement of the effluent can be accomplished by subjecting the present effluent to a third stage of treatment.

This third stage of treatment could conceivably consist of rapid sand filtration or micro-straining as practiced in the water purification field. Results obtained from experimental work conducted at Los Angeles have been very promising, as have the results from experiments at Luton, England. From the conclusions reported from these experiments, it is reasonable to assume that up to 50 per cent removal of BOD from secondary effluent could be attained. It is recommended that the Metropolitan Sanitary District institute studies to determine the feasibility of the use of third-stage treatment at the treatment plants.

Cooling Water Use

In maintaining a dissolved oxygen goal in a stream containing a residual organic pollution load, it is generally recognized that greater dilution flows are required under warm summer water temperature conditions than under cold winter water temperatures. The reason lies in the lower dissolved oxygen saturation values and the higher rates of biological activity at the higher temperatures. Temperature observations made during the sample collection program showed a rise of 9°C in temperature through the Sanitary and Ship Canal. This rise may be attributed to a combination of a natural increase in the cool

lake temperatures plus the use of the water for cooling by air conditioning and thermal power installations. The importance of this factor increases as the temperature rise becomes greater and as the dissolved oxygen goal is set higher.

To assure the preservation of the stream's capacity to assimilate organic waste residues without nuisance conditions, it is important that use of the flow in the Sanitary and Ship Canal for cooling water by air conditioning, industrial, and thermal power installations be regulated and limited.

REDUCTION IN INDUSTRIAL WASTE DISCHARGES

The known and evaluated sources of industrial wastes discharged directly to the Illinois River System is 971,000 PE as detailed in a previous report. A load of 511,000 PE is contributed to the river system between Lake Michigan and the Kankakee River, and 460,000 PE is contributed in the section from the Kankakee River to the Spoon River. There is no significant industrial pollution to the river system below the junction of the Spoon River.

This industrial pollution is contributed chiefly by the highly industrial areas of Chicago, Joliet, and Peoria-Pekin. The known and evaluated sources of industrial wastes discharged directly to the river system within the boundaries of the Metropolitan Sanitary District total 291,000 PE or approximately 30 per cent of the total industrial load. The industrial load contributed in the Peoria-Pekin area is 400,000 PE or approximately 40 per cent of the total load. The industrial load contributed in the Joliet area is 178,000 PE or approximately 20 per cent of the total load. The remaining 10 per cent of the industrial load is contributed to the tributaries and other sections of the river.

Chicago Area

The total waste load, domestic and industrial, to the three principal sewage treatment plants of the Metropolitan Sanitary District is 8,030,000 PE. The population served by these plants is 4,750,000. The difference, industrial wastes and other wastes treated by the plants, is 3,280,000 PE.

The known and evaluated sources of industrial wastes discharged directly to the Illinois River System within the boundaries of the MSD total 291,000 PE. A comprehensive survey of visible independent outfalls to the river system conducted by MSD indicated about 1300 such outfalls. Over 400 of these outfalls were observed and sampled by the Public Health Service and 140 outfalls were found to be contributing a significant load to the river. The significant outfalls have been included in the inventory presented in a previous report. The existence and number of submerged outfalls is unknown.

Extensive sampling by the Public Health Service of the waterways between Wilmette and Lockport (North Shore Channel, North Branch Chicago River, Chicago River, South Branch Chicago River, and Sanitary and Ship Canal) has indicated a pollutional load of approximately 400,000 PE in addition to the known loads from sewage treatment plants, Calumet-Sag Channel, and other influent streams. The known industrial waste load in the same section of the river is 225,000 PE. The difference between the industrial waste estimate of 225,000 PE and the known pollution load of 400,000 PE is attributed to storm-water overflow, by-passing untreated sewage, and unaccounted-for sources.

The MSD prohibits by ordinance (4)(5) the discharge to the waters of the district of wastes that are more concentrated than the effluent from the sewage treatment works of the district.

The MSD controls the quality and quantity of industrial wastes admitted to the sewage works, watercourses, or natural outlets within the boundaries of the Sanitary District in accordance with provisions of the MSD Ordinance of July 13, 1962 (5).

Industries discharging wastes to the MSD sewerage system are now subject to a charge based on their assessed valuation. A system of sewer service charges based on the quantity and characteristics of discharged wastes would induce industries to decrease the quantity and strength of their wastes by altering manufacturing methods, improving housekeeping practices, developing of new treatment and/or pre-treatment procedures, reusing waste water, segregating cooling water, and other methods of minimizing charges. The City of Cincinnati made a five-year study from 1954 to 1958 to determine the effectiveness of such a method of assessing sewer charges in reducing the industrial waste load (6). The Cincinnati survey represented a cross-section of heavy industry similar to that served by the MSD. The survey indicated that the volume of waste decreased about 10.4 per cent, the BOD about 13.3 per cent, and the suspended solids about 51.9 per cent.

The discharge of a portion of organic industrial wastes to the river system has been controlled by the Metropolitan Sanitary District by connecting the entire flow of waste from some plants into the sewerage system. However, in other cases the organic wastes have been segregated for discharge to the sewerage system, and larger flows relatively free of organic material have been allowed to flow to the river.

Many problems created by the discharge of industrial effluents to the river and sewerage system have been investigated by the MSD over the past 30 years. The MSD has conducted more than 900 separate studies of approximately 400 plants. The principal purpose of studying discharges to the sewerage system has been to detect and exclude such materials as oil, heavy metals, and others that interfere with proper operation of the treatment plants.

The industrial wastes program of the MSD is under the direction of the Director of Laboratories, who is responsible to the Chief Engineer. The number of people assigned to industrial wastes permits study of approximately 25 to 30 plants per year. The present staff and program of the MSD concerned with industrial waste discharges function effectively. However, enlarged operations are needed to provide complete surveillance of outfalls and industrial plant discharges to the River system.

Peoria-Pekin Area

The known and evaluated sources of industrial wastes discharged directly to the Illinois River in the Peoria-Pekin area is 400,000 PE. A survey of 43 outfalls in this area by the Public Health Service was made in order to verify this industrial waste load. Approximately 50 per cent of this load was found to be contributed by one source.

In general the highly concentrated industrial wastes are either connected to the sewerage systems or discharged to the river following pre-treatment. Some of the industries in this area recover valuable by-products from their waste waters.

Recommendations

1. The industrial waste program of the Metropolitan Sanitary District of Chicago should be expanded to permit more adequate surveillance of independent discharges to the river and the sewerage system.

2. Other municipalities along the Illinois River System should undertake industrial waste surveillance programs similar to the MSD program.

3. Industrial pollution should be decreased by treatment at the site if needed or by connection to a municipal sewerage system.

4. Comprehensive industrial waste ordinances should be adopted by all municipalities having sewerage systems to control the discharges of wastes to the sewerage systems.

COMBINED SEWERS

Present Conditions

Chicago Metropolitan Area

The Chicago combined sewer system includes over 3,600 miles of sewers serving 190 square miles and about 3.5 million population. Most suburban municipalities in the Metropolitan Sanitary District (MSD) are also served by combined sewer systems which discharge mixed sanitary and storm sewage to the Illinois River System during wet weather. There are about 200 overflows located on the main channels in the Chicago area, and an undetermined number on tributary streams.

The discharge of raw sewage and industrial wastes mixed with storm water during rainstorms constitutes a sizeable intermittent source of pollution to the waterways. Although the discharge of combined sewage at such times is of limited duration, solids deposited as sludge on the stream bed may persist and deplete the flowing water of dissolved oxygen (DO) for extended periods of time. The raw sewage discharged also contributes substantially to the flowing pollution load of the stream. This tends to depress the DO profile and extend the recovery time. Such sources of raw sewage contribute unsightly floating matter and create potential and actual hazards from pathogenic organisms.

Lower Illinois River

In the Lower Illinois River Basin there are 22 cities with a population of 5,000 or more which are served by combined sewers. The estimated total population served in this group is 438,000. In addition there are 12 cities in this population class which are served by both separate and combined sewers. The latter group includes Peoria, and the estimated total population served by separate and combined sewers in these cities is 371,000. Many smaller towns in the basin also have combined sewer systems. Needless to say, not all of these combined sewers overflow simultaneously. However, the discharge of raw sewage to the Illinois River is deleterious to the water quality, and is a potential hazard to public health.

Improvement Measures

Chicago Metropolitan Area

Methods by which reductions in combined sewage spillage could be accomplished are discussed below.

Separation of storm water and sanitary sewage at the source is probably the ultimate solution to the problem, but its implementation would be so complicated, time consuming, and costly that results would not be realized for a number of years. However, consideration should be given to a program similar to that in effect in Washington, D.C. (7), which provides for a master plan to coordinate all new building construction, private development, civic improvements, and

redevelopment into a program leading to the complete separation of storm and sanitary sewers. It is believed that within a few years many other cities will follow Washington's example. There is much new construction under way in Chicago, and it would be possible to provide separate sewers at the time areas are redeveloped, so that at some time in the future, when enough of the city has undergone such change, it would be practicable to connect these separate sanitary sewers directly to the interceptors, and to use the existing combined sewers for storm water only. A number of the suburban communities now served by the MSD have separate sewer systems. In some cases the two systems are so interconnected that separation would be very difficult and may not be justified at this time. A program of gradual separation could be started, however, which would result in complete separation in the future.

The industrial waste load to combined sewers could be reduced in areas where industries are located near an interceptor, by separating industrial and domestic wastes from storm water and delivering these wastes directly to the interceptor.

In general, the interceptors should have capacity for twice the average daily dry weather flow. When the interceptors become overloaded, more frequent spills occur. This is a problem associated with the rapid urban growth within the MSD. Studies should be made to determine whether the reduction of these overflows should be accomplished by construction of one or more large sewage treatment plants in the outlying areas, or by the construction of relief interceptors to transport the sewage to existing treatment plants.

Since the strength of sewage varies considerably in different parts of the collector system, consideration should be given to providing a higher interception ratio in areas where waste concentrations are greater. The Sanitary District now does this in some instances. Additional study would indicate where this method could be extended advantageously.

The existing treatment plants should have capacity to treat twice the average daily dry weather flow. The MSD has planned additions to the three main plants which will provide this capacity by 1970.

Primary sedimentation tanks for storm flow would be effective for reducing settleable solids and BOD. The maximum reduction in BOD with adequate retention time would be about 40 per cent (1) in the flow passing through the tanks. Detailed studies would be required to determine the economical size of storm water treatment plants in relation to their effect on the waterway. Such studies should also include the feasibility of disinfection for reduction of bacterial pollution.

Lower Illinois River

Possible measures for reduction of pollution due to combined sewers in municipalities in the Lower Illinois River Basin are listed below. Economic studies would be required in each case to determine the most suitable combination of measures.

Separation of storm and sanitary sewer systems.

Adequate design of new interceptors, and construction of relief interceptors where needed to reduce frequency of spills.

Provision of adequate design capacity at new or existing treatment plants.

Primary treatment tanks for storm flows.

OTHER QUALITY CONTROL MEASURES

Research Toward More Efficient Treatment Methods

The Chicago metropolitan area presents a challenging and exceedingly difficult water pollution control problem because of the tremendous waste loads and the scarcity of dilution water.

The Metropolitan Sanitary District of Greater Chicago, within which the great bulk of the loads originate, has provided sewage treatment facilities representative of the best available practical methods known for secondary treatment of organic waste discharges. These fail to eliminate the stream pollution problem, the effect of which is not only serious locally but also is potentially hazardous to downstream users.

There are major deficiencies in the best of current sewage treatment practices to control water pollution. The treated effluents contain nutrients which stimulate aquatic growths such as algal blooms and result in nuisances to downstream water users, persistent organic chemicals such as alkyl benzene sulfonate (ABS) which are not removed by water supply treatment processes, and suspended and dissolved organic residues that exert an oxygen demand in excess of the oxygen available in the limited amount of dilution water. Such are the conditions which exist in the Illinois River System in which the Chicago metropolitan area discharges its wastes. A breakthrough in knowledge of sewage collection and treatment methods is one of the avenues that can lead to the solution of these problems. The need for better technology is further highlighted by the recent finding of latent oxygen demand exerted in downstream reaches of the Illinois River. This latent demand, attributable to oxidation of nitrogen residues from upstream wastes, points to the need for serious study in the removal of more than carbonaceous matter.

The MSD has legal authority for water pollution control within its territory, along with a responsibility to downstream users to provide the solution to problems of water quality caused by the use of the Illinois River System for disposal of its wastes. It is therefore incumbent upon the district to be in the forefront of a vigorous program of research and development of advanced treatment methods.

The 1960 National Conference on Water Pollution (8) concluded that a much greater effort is needed to provide a scientific basis for technological progress in water pollution control and recommended a national research effort of 15 million dollars per year by 1970. It also pointed to the need for greater awareness and appreciation of research by the practitioners -- dischargers, regulators, designers, and educators as well as the general public. The conference further pointed up areas of research effort needed, including advanced treatment methods.

It is recommended that, in keeping with its responsibilities to provide adequate control of water quality for downstream uses, the MSD expand its program of research and development in advanced waste treatment methods.

Flexibility in Diversion

The Metropolitan Sanitary District is limited by Supreme Court decision to an annual average lake water diversion, exclusive of domestic pumpage, of 1,500 cubic feet per second (cfs). This allowable diversion includes an annual average of about 500 cfs of runoff to the waterway which would be tributary to Lake Michigan if the natural direction of flow of the streams involved had not been reversed. The annual average within each calendar year may not exceed the allowable 1500 cfs. The total flow in the waterway is measured at Lockport, and the diversion flow is computed by subtraction of domestic pumpage and inflows to the system from areas which were tributary to the Des Plaines River before the canals were built. The sanitary district (9) operates the system on an annual water budget with the objective of maintaining average monthly flows at Lockport which experience has shown to be consistent with seasonal conditions on the waterway, and with demands of navigation. The diversion in a typical year averages approximately 400 cfs at Wilmette, 500 cfs at mouth of Chicago River and 600 cfs at Blue Island Controlling Works.

Since one-third of the total diversion is uncontrolled runoff, the short-term diversion rates may differ radically from the annual averages given above, particularly during heavy runoff periods. At such times, direct diversion at Wilmette and at mouth of Chicago River may be discontinued. At Blue Island, diversion may be limited to that amount necessary to maintain navigation through the lock. These restrictions of flow are necessary to prevent flood damage along the channels during major storms.

Thus, one-third of the total diversion, on the average, is uncontrolled, and the use of the other two-thirds for dilution is restricted by the requirements of navigation and by the chance occurrence of rainfall. In any particular year the flow regulation necessitated by abnormal runoff, together with the limitations imposed by the Supreme Court, may result in degrading the waterway during a portion of the year.

Abnormal rainfall distribution during the year 1961 produced a condition which illustrates the point. Total rainfall during the first eight months of the year was 0.96 inches below the normal of 22.65 inches at Midway Airport, and the eight-month average diversion rate (1,618 cfs) was slightly above the allowable average for a whole year. During September a total of 14.17 inches of rainfall occurred, producing uncontrolled runoff which increased the average diversion flow to 1,774 cfs for the months January through September. It was then necessary for the sanitary district to reduce direct diversion to a minimum during October and November, 567 and 385 cfs respectively, in order to comply with the 1,500 cfs average requirements at the end of the year. Sampling runs were made on October 17 and 25, during the period of reduced diversion. Dissolved oxygen (DO) profiles for these dates are shown on Figure 1, together with the average DO profile for the sampling period April 24 - May 21, when average diversion was 1,800 cfs. Degradation of the stream during the period of reduced diversion is evident.

In order to improve the stream during conditions such as described above, it would be desirable to change the basic accounting period for diversion flows from the calendar year to a water year terminating at the end of February. The diversion flow required to maintain the DO objective at Lockport is much less during the winter months than during

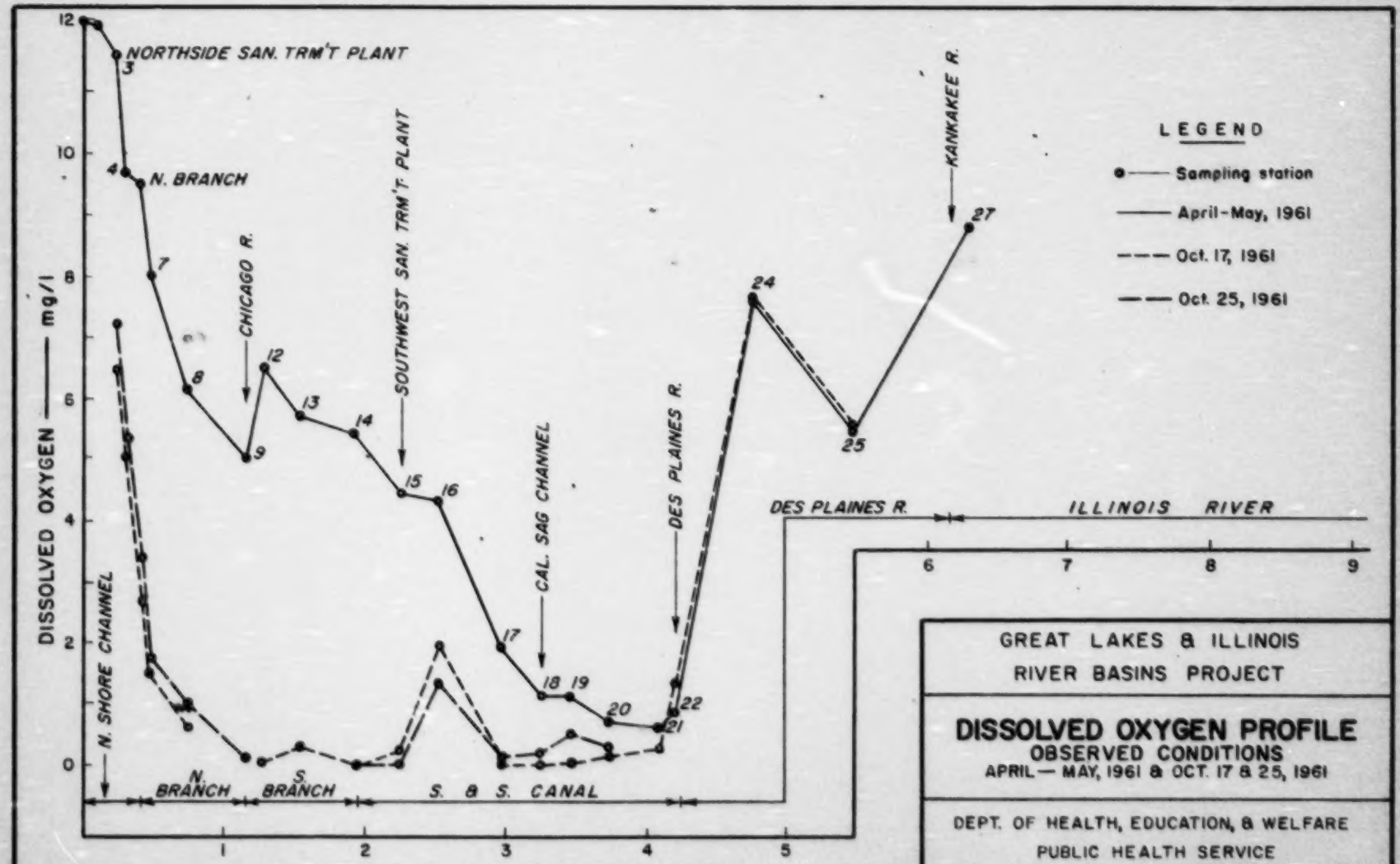

DISSOLVED OXYGEN —— mg/l
TIME OF TRAVEL-DAYS DOWN MAIN STEM
NORTHSIDE SAN. TRM'T PLANT
N. BRANCH
CHICAGO R.
SOUTHWEST SAN. TRM'T. PLANT
CAL. SAG CHANNEL
DES PLAINES R.
KANKAKEE R.
N. SHORE CHANNEL
N. BRANCH
S. BRANCH
S. & S. CANAL
DES PLAINES R.
ILLINOIS RIVER
LEGEND
Sampling station
April-May, 1961
Oct. 17, 1961
Oct. 25, 1961
GREAT LAKES & ILLINOIS RIVER BASINS PROJECT
DISSOLVED OXYGEN PROFILE
OBSERVED CONDITIONS
APRIL — MAY, 1961 & OCT. 17 & 25, 1961
DEPT. OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION V
CHICAGO, ILLINOIS

FIGURE 1

the remainder of the year, and it would be helpful if the months of low diversion demand were at the end of the accounting period. An analysis of the average monthly diversion flows for the period 1953-1960, compared to the average monthly flows required to maintain desirable DO levels at Lockport during the same period, indicates that the diversion water year should begin on March 1. This would permit a better utilization of the water available for dilution.

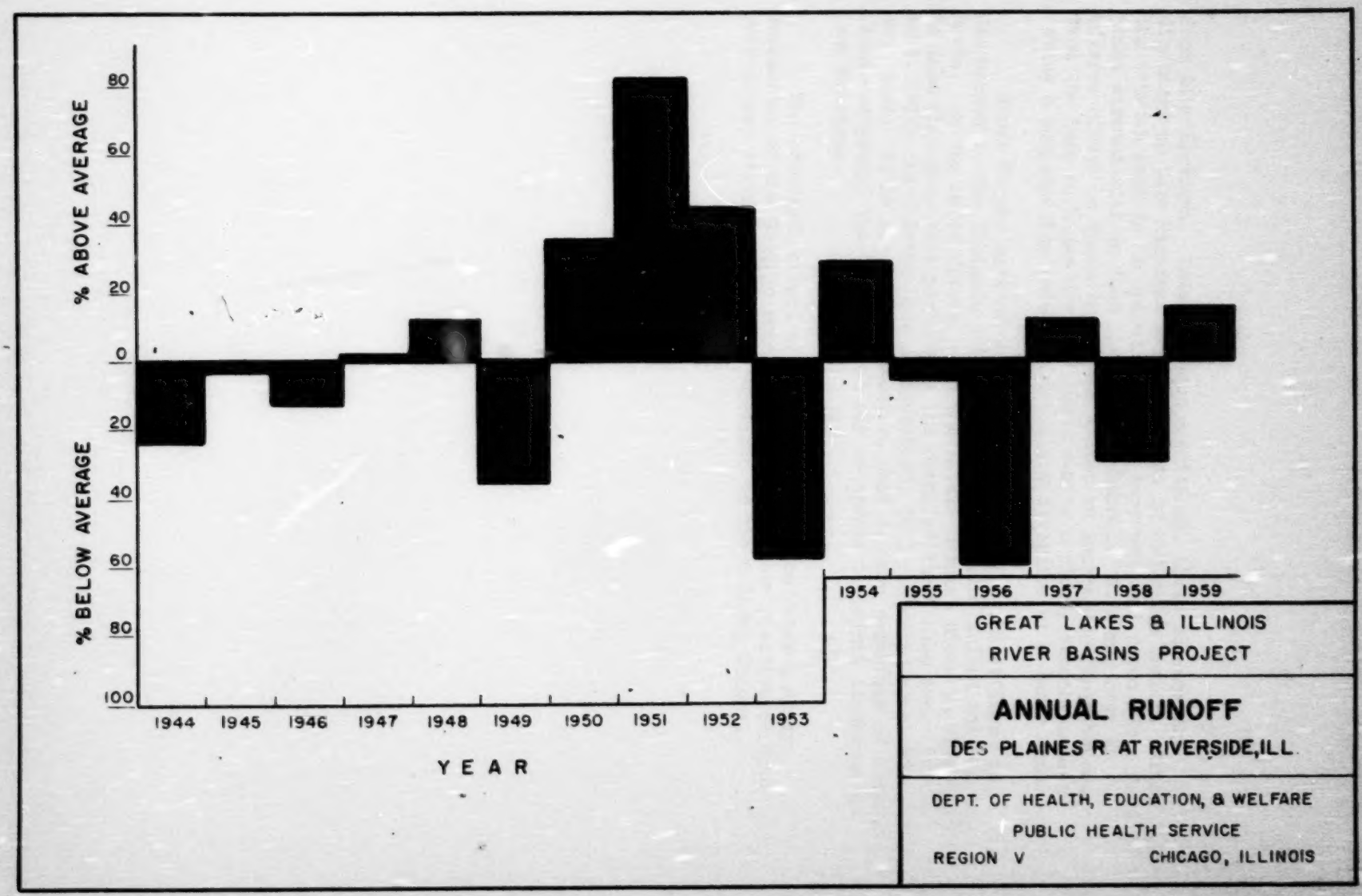
The extent to which the runoff may vary is indicated on Figure 2, which shows annual runoff in per cent above or below the average for the U. S. Geological Survey gaging station on the Des Plaines River at Riverside, Ill., during the period of record (1944-1959). The Des Plaines River Basin is adjacent to the area draining to the Sanitary Canal and both would receive essentially the same annual rainfall. Variations in average monthly flows are much more extreme and have a greater effect on actual operation of the waterway. Because of the large variations in flow which do occur, it is recommended that the accounting method be modified to permit two years for achieving the required balance, when necessary. In other words, on any March 1 when the average diversion for the preceding 24 months has not exceeded 1,500 cfs, two years would be available for achieving the next balance. Thus, the incentive would be to maintain the 1,500 cfs average in 12 months in order to have the subsequent 24 months available in case of emergency.

Thomas J. O'Brien Lock

The O'Brien Lock and Dam was constructed by the Corps of Engineers, U. S. Army, as a part of the Calumet-Sag Navigation Project. The new lock will replace the Blue Island Controlling Works, constructed in 1922 by the sanitary district. The O'Brien Lock is located on the Calumet River, Mile 326.5, about midway between the mouth of Grand Calumet River and the 130th Street Bridge. Four 10-foot square sluice gates are provided in the dam, which will serve to regulate flows from Lake Michigan to the Illinois Waterway, to prevent reversals of flow into Lake Michigan, and to permit better control of water levels landward of the lock.

At the present time, towboats are permitted to proceed through the Blue Island lock under power with both lock gates open. This method of operation, necessitated by the inadequate size of the lock, permits a large uncontrolled flow from Lake Michigan, estimated to average about 600 cfs. With the O'Brien Lock in operation, all tows will be locked through in the conventional manner, with consequent reduction in water usage due to lockage requirements. It is estimated that about 150 cfs will be needed to operate the O'Brien Lock after completion of the Cal-Sag Navigation Project.

The Little Calumet and Grand Calumet Rivers enter the Illinois River System between the Blue Island and O'Brien Locks. These rivers were originally in the Lake Michigan watershed. As a result of the construction of the Cal-Sag Channel, they now contribute to the Illinois River System, and their flow is charged against the allowable diversion



GREAT LAKES & ILLINOIS
RIVER BASINS PROJECT

ANNUAL RUNOFF

DES PLAINES R. AT RIVERSIDE, ILL.

DEPT. OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION V CHICAGO, ILLINOIS

FIGURE 2

SUMMARY

1. No less than secondary treatment should be provided for all sewage being discharged to the Upper Illinois River System and the main stem below Lockport.

2. The Metropolitan Sanitary District should undertake an extensive study to determine the best plan to attain the recommended goal on stream coliform density. The technical practicability of disinfecting the canal at several locations and/or the disinfecting of treatment plant effluents and storm water overflows should be studied.

3. The Metropolitan Sanitary District should continue its present experimental program of artificial reaeration of the river system in order to determine whether it is practical to increase oxygen concentrations by this method under the conditions that prevail.

4. The recently enacted industrial waste ordinance should be reviewed for possible revisions that will encourage industrial practices which minimize the quantity and strength of industrial wastes delivered to the MSD sewer system.

5. The Metropolitan Sanitary District should continue the program for the detection of unknown submerged outfalls, illegal connections to storm sewers, and other types of illicit connections.

6. The use of the canals in the Chicago area for cooling water by air conditioning, thermal power, and industrial installations should be regulated and limited.

7. The MSD and other responsible agencies should increase the emphasis given to research and development programs for improvement of treatment techniques and other measures to protect the quality of receiving waters.

8. The Metropolitan Sanitary District should immediately undertake comprehensive engineering studies to determine the best plan for the separation of storm and sanitary sewers, and the plan should be implemented as it becomes available. Suggested short-term improvements should be made in the meantime.

9. The "water year" for computation of the average allowable diversion should begin on March 1, and should continue for a two-year period if necessary for balancing the water account when circumstances dictate, to foster better utilization of the authorized diversion.

REFERENCES

1. Babbitt, H. E. and Baumann, E. R. Sewerage and Sewage Treatment. John Wiley & Sons, Inc., New York (Eighth Edition, 1958).

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6. Sewage Disposal, Ninth Annual Report, Cincinnati, Ohio (1958). p. 19.

7. Sewer Separation Program for Washington, D.C., Department of Sanitary Engineering, District of Columbia Government (1960).

8. Proceedings of the National Conference on Water Pollution, Dept. of Health, Education, and Welfare, Public Health Service, Washington, D.C. (1960).

9. Metropolitan Sanitary District of Greater Chicago, Engineering Department, Maintenance and Operating Division, Twenty-Eighth Annual Report (1961).

REPORT

ON THE

ILLINOIS RIVER SYSTEM

RECOMMENDED MEASURES FOR IMPROVING WATER QUALITY

JANUARY, 1963

U. S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE

PUBLIC HEALTH SERVICE

DIVISION OF WATER SUPPLY AND POLLUTION CONTROL

GREAT LAKES-ILLINOIS RIVER BASINS PROJECT

ERRATA

Recommended Measures for Improving Water Quality

Page 1, second paragraph, first sentence.
Delete 1,450,000 PE: insert 1,590,000 PE.
Delete 970,000 PE: insert 830,000 PE.

Page 2, first paragraph, third line. Insert asterisk after 930,000 PE.
At bottom of page insert: *In addition to this stated load, a malfunctioning storm relief discharged an estimated 144,000 PE during the period of study.

Page 6, fourth paragraph, third line. Delete 291,000 PE; insert 147,000 PE.

Page 7, first paragraph, eighth and ninth lines. Delete 225,000 PE; insert 81,000 PE.

Recommended Measures for Improving Water Quality

ADDITIONAL ERRATA

Page 6, first paragraph, second line. Delete 971,000 PE; insert 827,000 PE.

Page 6, first paragraph, third line. Delete 511,000 PE; insert 367,000 PE.

Page 6, second paragraph, fifth line. Delete 291,000 PE; insert 147,000 PE. Delete 30; insert 20.

Page 6, second paragraph, seventh line. Delete 40; insert 50.